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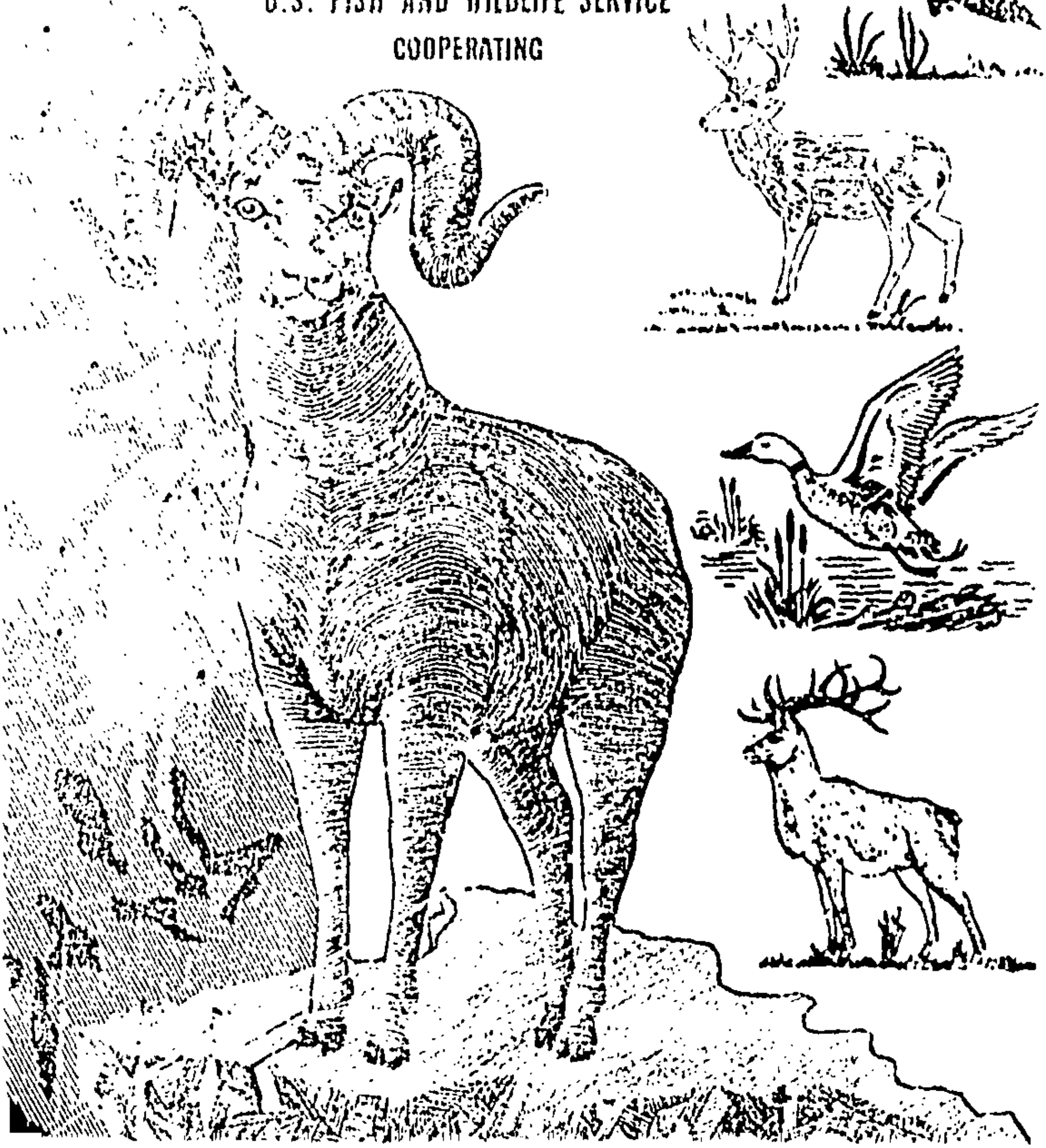

UPTAKE, EXCRETION, AND DISTRIBUTION OF ZINC-65 BY THE MALLARD*

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INTRODUCTION

Radioactivity in the natural environment seems certain to increase as peaceful uses of atomic energy continue to be developed. Wastes entering the aquatic environment from power reactors, waste disposal, and weapons testing, are of considerable importance since these radionuclides may eventually pass to man via the food chain. The pathways by which aquatic wastes travel from one trophic level to the next in the natural environment are complex. One possible, direct implication of the biotic radionuclide transport system to man is that of highly mobile, migratory bird species.

During 1966-67 our research investigated the uptake, excretion, and tissue distribution of the radionuclide ^{65}Zn by the mallard duck (Anas platyrhynchos). ^{65}Zn is a strong gamma ray emitter, and is an activation product of water-cooled reactors (Fig. 1). This and the fact that ^{65}Zn is universally distributed has stimulated its use in our research. The mallard was chosen as the study species because it represents approximately 30 percent of the migratory waterfowl population; it has close interaction with man's habitation; and it is prominent in hunter kills, being first in three flyways and important in the fourth (Waterfowl Status Report, 1966).

Specifically, our study has been related to the Columbia River Basin of Washington, Oregon, and Idaho which has had a wintering mallard population of over 600,000 birds for the past 12 years. During the time spent in the basin, some of the mallards are known to have become contaminated with trace amounts of several different radionuclides, including ^{65}Zn, by feeding on aquatic organisms which concentrated these radionuclides from effluent waters from the Hanford reactors in Washington. An important implication relates to the fact that a large number of highly mobile migratory waterfowl pass through the Columbia Basin area in which a portion of the aquatic environment is contaminated with radionuclides. These nuclides may pass to man via the food chain.

Our studies have investigated ^{65}Zn metabolism in the mallard in an attempt to add basic knowledge about pathways of readily metabolized radionuclides.

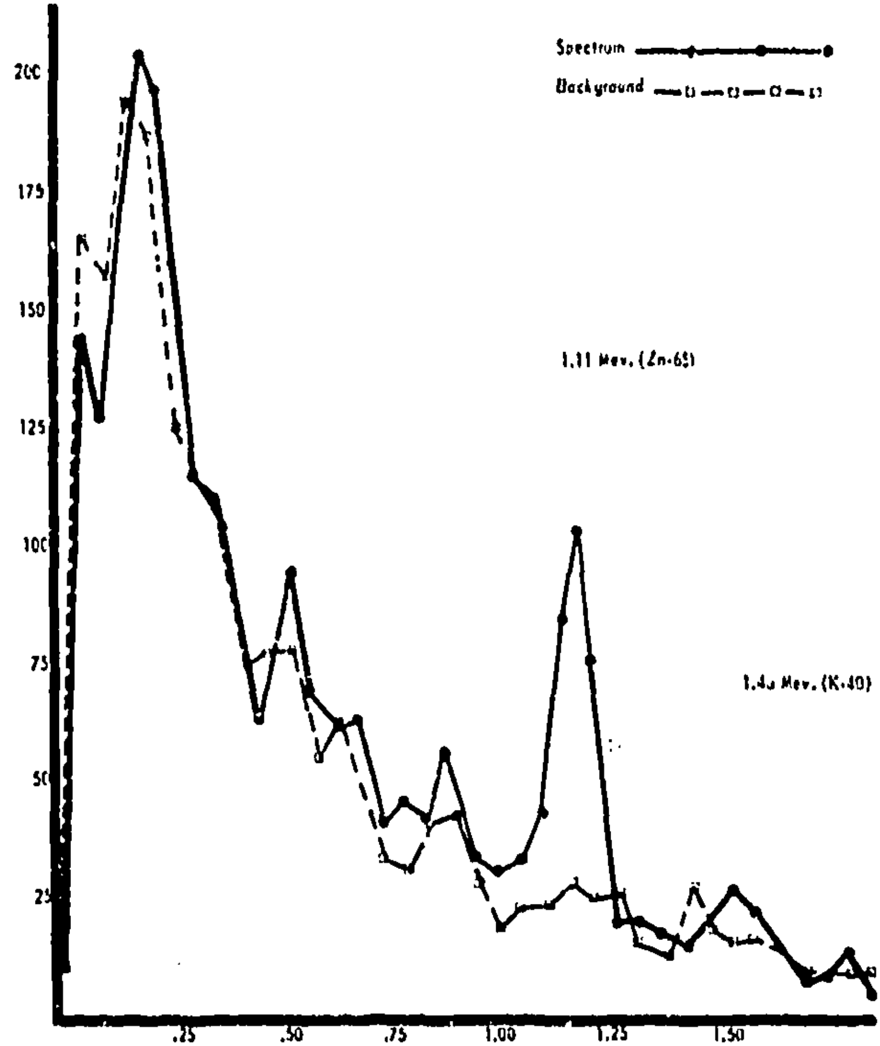

Figure 1. Composite gamma-ray spectrum of a wing from a female mallard collected in Clatsop County, Oregon, which contained significant quantities of Zn-65.

METHODS AND MATERIALS

A total of 40 adult mallards was used in experiments with treated water and food. The 40 birds were divided into two groups of 20, one group receiving treated food and the other treated water, each consisting of an equal number of hens and drakes.

Over a 30-day period, the food-treated study group was force-fed gelatin capsules containing 1 uc of ^{65}Zn absorbed into feed granules. The dosage was fed to each of the 20 mallards, every 2 days. Whole body counts were made between spikings for the 30-day experimental period and for an additional 30 days after termination of ^{65}Zn feeding. Total ^{65}Zn activity administered to each bird in the feed experiment was 14-15 uc. Whole body counting was accomplished with a small whole body counting chamber, 2"x[illegible] NaI (Tl) crystal and an integral scintillation counter.

Water treatment was carried out by simultaneously placing 20 birds in a 2'x6' water tank containing water treated with 10 uc, $^{65}Zn/1$. The birds received contamination by body absorption from the water and by drinking the water. After the initial water-treatment experiment, in which all 20 mallards were contaminated, the birds were separated into two groups of 10, one group being given free access to untreated water, while the other group was limited to untreated drinking water only.

It was thought that by having one study group with free access to untreated water and the other group with limited access to untreated water, one could possibly determine if or how readily surface ^{65}Zn contamination is retained by the mallard.

Thirty days after the initial water treatment a second experiment was conducted with the free access group only. The limited water access group was used as a comparison to indicate if differences existed in the ^{65}Zn decay rate between the two groups.

When all whole body counts on all experimental birds were completed, they were sacrificed for ^{65}Zn tissue assay.

RESULTS

It was found from the food treatment experiment that of an individual oral dose of ^{65}Zn, 86.5 percent was excreted and 13.5 percent retained by the mallard. Statistical analysis of uptake data has not been completed, but from uptake data observation it is seen that the hen ^{65}Zn uptake rate appears not to be as great as that of drakes. This is probably due to the faster turnover and excretion of ^{65}Zn by hens, as found by analysis of the decay curve data. Drake ^{65}Zn biological half life was found to be 76.7 days, hens 67.9 days, with a mean of 72.3 days (Table 1).

From the water treatment experiment it was found that after 27 days, the whole body activity of the free access group was nearly 18 percent lower than that of the 10 mallards with drinking water access only (Fig. 2). Decay curve data analysis of the two water treatment experiments shows that a significant difference ($P < .005$) exists due to the rinsing effect of the uncontaminated water.

The biological and effective half lives of the study group with free access to uncontaminated water was found to be 47.4 days and 39.4 days respectively, while the biological and effective half lives of the group with limited access to water was 67.2 days and 53.2 days respectively (Table 2). The difference of 19.8 days in the biological half life of ^{65}Zn between the free and limited water access groups indicates that over 29 percent of the surface radionuclide contamination can be removed by uncontaminated water over a 30 day access period.

It should be kept in mind that our data were collected from penned

Table 1. Feed-spiked mallard ^{65}Zn decay curve "b" values and biological half lives.

Sex	Mallard No.	b	Biological half life (days)
Male	1	-0.008	87
	2	-0.008	87
	3	-0.009	77
	4	-0.009	77
	5	-0.011	60
	6	-0.009	77
	7	-0.010	69
	8	-0.009	77
	9	-0.009	77
	10	-0.009	77
Female	1	-0.009	77
	2	-0.009	77
	3	-0.011	63
	4	-0.010	69
	5	-0.011	63
	6	-0.012	58
	7	-0.010	69
	8	-0.009	77
	9	-0.011	63
	10	-0.011	63

mallard ducks. Free roaming, migratory waterfowl may exhibit a different rate of surface ^{65}Zn elimination depending upon the amount of time spent in uncontaminated waters.

Figure 2. Elimination of ^{65}Zn from mallards which were externally contaminated.

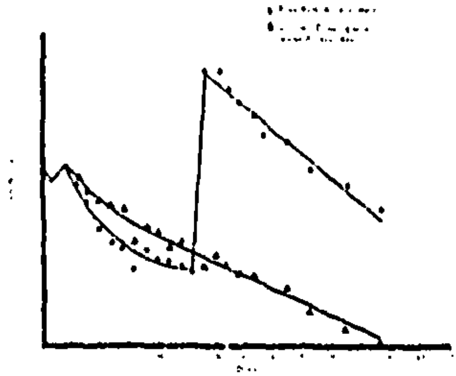

Table 2. ^{65}Zn half life in the mallard.

Treatment	No. Ducks/ Treatment	Mean Biological $T_{1/2}$ Days	Mean *Effective $T_{1/2}$ Days
FEED SPIKED			
Male + Female	20	72.3 ± 8.4[+]	55.6
Male	10	76.7 ± 7.1	58.5
Female	10	67.9 ± 7.0	53.3
WATER SPIKED (Limited H_2O Access)			
Male + Female	7	67.2 ± 9.7	53.2
Male	3	74.4 ± 4.4	56.8
Female	4	62.5 ± 9.6	49.5
WATER SPIKED (Free H_2O Access)			
Male + Female	10	47.4 ± 10.9[‡]	39.4
Male	5	56.1 ± 9.2	45.6
Female	5	38.8 ± 3.4	33.6

$$^{*}T_{eff} = \frac{T_b \times T_p}{T_b + T_p}$$

T_b = biological half life
T_p = physical half life (245 days)
Teff = effective half life

[+] Significantly different ($P < .005$) from T_b of water-spiked (free H_2O access mallards).

[‡] Significantly different ($P < .005$) from T_b of both feed-spiked and water-spiked (limited H_2O access).

From data analysis it was found that the mallards given treated food and treated water with limited water access have similar decay curves, there being no significant difference between the mean biological half lives of the two groups ($P < .005$). However, it was found that the biological half lives of mallards given treated water with free access to untreated water were significantly different ($P < .005$) than the biological half lives of the group with limited access to water, as well as the biological half lives of the food-treated group.

After the experiments were completed and the study mallards sacrificed, tissue ^{65}Zn assay was begun. Wet ashing with concentrated nitric acid was used to determine the relative ^{65}Zn tissue distribution in the mallards.

Based on net counts per minute per gram of fresh tissue, the relative distribution for the 12 highest specific activity tissue complexes are as follows (highest to lowest): adrenal glands, pancreas, intestine, femur, pectoral girdle, leg muscle, kidney, lung tibia, heart, bill, and liver. Whole wings and body skin plus feathers each had relatively high specific activity (counts per minute per gram of fresh tissue) in comparison to wet ashed tissue samples, but could not be justly compared because wing and body skin plus feathers were not wet ashed. Wet ashing wings and body skin with feathers will be carried out in further tissue assays.

Spleen tissue was found to contain no detectable ^{65}Zn in 80 percent of the birds assayed, regardless of sex or treatment. Though high variability was found in the relative amount of ^{65}Zn in given tissues from different birds, it was found that the adrenal tissue samples were consistently among the three highest activity samples for any given bird; and, in 40 percent of the mallards assayed the adrenal samples had the highest specific activity of all tissues assayed.

From count data of whole wings and body skin plus feathers, it was found that, in the water-treated mallards with free access to uncontaminated water, wing specific activity was 134 percent higher than the specific activity of skin and feathers, sexes combined. In the food-treated mallards, wing specific activity was only 12.9 percent higher than that of the skin plus feathers.

Another interesting difference in relative ^{65}Zn distribution in the water-treated mallards occurred between leg and breast muscle samples. Specific activity of leg muscle was 510 percent higher than breast muscle for both sexes combined.

These experiments show the importance of access to uncontaminated water as well as giving a better insight into the distribution of radionuclides by waterfowl from one water system to another.

LITERATURE CITED

Hansen, H. A. and M. R. Hudgins. 1966. Waterfowl Status Report, 1966. Bureau of Sport Fisheries and Wildlife Special Science Report, Wildlife No. 99, October, 1966. Government Printing Office, Washington, D.C. 95 p.